

DETERMINING THE EFFECT OF PROBLEM-BASED LEARNING INSTRUCTIONAL STRATEGY ON NCE PRE-SERVICE TEACHERS' ACHIEVEMENT IN PHYSICS AND ACQUISITION OF SCIENCE PROCESS SKILLS

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Abstract

Physics is the foundation of science and technology. Students achievement in this subject at all levels of Education had been consistently poor. In an attempt to seek solution to this problem this study determined the effect of problem-based learning on NCE pre-service teachers' achievement in physics and acquisition of science process skills. The study adopted a quasi experimental research design with 98 females and 94 males from six colleges of education in South Western Nigeria constituted the sample. A treatment group was exposed to the problem-based learning instructional strategy and a control exposed to the conventional lecture method. The treatment was found to have significant effect on pre-service teachers' achievement in physics $F_{(2,185)} = 43.441$, $p < .05$ and science process skills $F_{(2,175)} = 183.803$, $P < .05$. In achievement in physics students exposed to problem-based learning obtain higher post test score ($\bar{x}=51.98$) than those exposed to conventional lecture method ($\bar{x}=30.23$). Also students exposed to problem-based learning strategy obtained higher science process skills score ($\bar{x}=73.67$) than those exposed to convention lecture method $\bar{x}=26.73$. It is concluded that problem-based learning strategy improves students' achievement in physics and acquisition of science process skills and is therefore recommended for use by lecturers in colleges of education.

Keywords: Problem-based learning, NCE pre-service teachers, Achievement in physics, Acquisition of science process skills

Introduction

In this age of science and technology, the role physics plays in the actualization of the needed technological advancement cannot be overemphasized. But this will remain a dream if the present poor state of students' performance in the subject is not addressed. Prominent among the factors which have been identified as contributing to the persistence of poor level of achievement in physics are: Inefficient teaching methods adopted by physics teachers in the field (Adepitan, 2003; Ivowi and Oludotun, 2001; Gbolagade, 2009), poor manipulation of science process skills (Aydogdu and Kesercioglu, 2005; Yesilyurt, Bayraktar and Erdemir, 2004 and Saat, 2004), learner variables such as gender stereotype in physics and lack of confidence by physics students in their approach to tackling physics problems (Babosa, 2003, Jimoh, 2004 and Riess 2000).

There seems to be a general consensus of opinion among science educators concerning the pivotal role played by the teaching method or instructional strategy adopted as classroom variables affecting students' achievement and attitude to science (Gbolagade, 2009). He emphasized the importance of appropriate teaching method in the development of skills required for making science content relevant to the growth and development of both the individual, the society and to meet the teacher's standards. He called for adequate training of teachers, which should include the introduction of appropriate methods of teaching the subject matter.

Duyilemi (2005) advised that students should be given opportunity to be actively involved in the learning process. This has therefore, created room for further search for other instructional strategies that could possess enough cure and appeal to the learners and that would help to achieve the objectives of science education. All these call for constructivist-based teaching strategy in science. Constructivism has emerged as one of the greatest influence on the practice of education in the last 25 years (Jones and Brader-Araje, 2009). This is because; constructivist-based instruction firmly places educational priorities on students' learning. Also, Kinshuk (2003) reported that it has been found that students are able to learn and retain knowledge better by actively participating rather than learning passively. Therefore, the researcher adopted a constructivist strategy: problem-based learning strategy which has not been given adequate attention in the NCE course outline. These perhaps, could be used to achieve the objectives of physics curriculum. More so, as pre-service teachers, they will use this strategy when they will be practicing as observed by Felder (1993) that teachers teach instinctively the way they were taught.

Problem-Based Learning is an educational approach in which complex problems serve as the context and the stimulus for learning (Major and Palmer, 2001). In PBL classes, students work in teams to solve one or more complex and compelling ‘real world’ problems. They develop skills in collecting, evaluating, and synthesizing resources as they first define and then propose a solution to a multi-faceted problem. Students also summarize and present their solutions. The instructor in a PBL class facilitates the learning process by monitoring the progress of the learners and asking questions to move the students forward in the learning process, the instructor is not the sole resource for content or process information, but instead guides students as they search out appropriate resources (Major and Palmer, 2001).

Iroegbu (1998) used PBL to teach some physics concepts: work, energy, power, heat capacity and latent heat to 202 senior secondary II students. The result showed a significant main effect of PBL on physics achievement. The obtained F-ratio was $F_{(3, 20)} = 10.248$, $P < 0.05$ with alpha level at 0.05, the critical F. ratio required for the rejection of the null hypothesis for the degree of freedom was 2.65, on using the multiple classification analysis (MCA), the result showed that the treatment main effect accounted for 12% $(.34)^2$ of the observed variance in the data. Based on the result obtained, he confirmed the potency of the PBL as an effective instructional procedure that could be used in reversing the current trend of under achievement in SSCE Physics examinations. He also found out that the use of PBL also promoted the acquisition of problem solving skills and line graphic skills.

According to Major and Palmer (2001), this strategy provides students with the opportunity to gain content knowledge and skills, it helps students develop advanced cognitive abilities such as critical thinking, problem solving and communication skills and improve students’ attitudes toward learning. Thus as a pedagogical strategy, problem-based learning promotes the kinds of active learning that many educators advocate (Barr and Tagg, 1995). Therefore, it is hoped that this strategy will help to improve the quality of pre-service teachers if it is used.

Statement of the problem

The persistent low achievement of students in physics has been a major concern to physics educators and researchers. Several factors have been adduced to be responsible for this trend, mainly the instructional strategy used in teaching physics such as the use of lecture method, inadequate science process skills, gender stereotype and lack of confidence in tackling physics problems. This study therefore determined the effects of problem-based

learning instructional strategy on pre-service NCE students' achievement and acquisition of science process skills in physics.

Research Questions

Based on the problem stated above, this study will be guided by the following research questions:

1. Will NCE students' performance depend on the instructional strategy employed?
2. Will acquisition of science process skills be affected by mode of instruction?

Hypotheses

This study is designed to provide answers to the following hypotheses at $p < 0.05$ level of significance.

- HO₁: There is no significant main effect of treatment on pre-service teachers' achievement in physics concepts
- HO₂: There is no significant main effect of treatment on pre-service teachers' acquisition of science process skills.

Methodology

A pretest posttest control- group quasi-experimental research design was adopted for this study. This design is schematically represented as follows:

Experimental group O₁ X₁ O₂

Control group O₁ X₂ O₂

Where O₁ represent the pre-test observations for experimental and control groups and O₂ represent the post test observations for experimental group and control groups

X₁ is experimental treatment group; problem-based learning strategy.

X₂ is control; conventional lecture method for group 3.

Selection of Participants

The target population for this study comprised all the NCE III pre-service teachers studying physics with other combinations in Colleges of Education in the South Western Nigeria. Three states and three federal Colleges of Education were purposively selected based on their offering physics as NCE course, having physics teachers and functional internet facilities. Three colleges were used as treatment group and the other three for control group. From the selected colleges, all available NCE III students offering physics were used for the

study. The lecturers used as instructors in the study were the regular physics lecturers assigned by the H.O.D to handle the course-Electromagnetism III (PHY 321).

Instrumentation:

The following research instruments were used in this study:

(A) Response instruments

- 1 Physics Achievement Test (PAT)
- 2 Science Process Skills Worksheets (SPSW)

(b) Stimulus instruments

- 3 Teachers' Instructional Guide on Problem Based Learning strategy (TIGPBLS).
- 4 Teachers' Instructional Guide on Conventional Lecture Method (TIGCLM).

Physics Achievement Test (PAT)

This is a researcher developed multiple choice objective test, made up of forty items. Each item has one correct option and four distractors. The instrument tested the pre-service teachers' intellectual achievement in ferromagnetism, electromagnet, force effect of current carrying conductor in magnetic field and electromagnetic induction.

Validity and Reliability of PAT

Originally the researcher constructed a test with eighty items for PAT. To establish PAT content and face validity, copies of the initial test draft that contained eighty (80) items were given to three physics educators and modifications based on their suggestions were made. This led to the dropping of nine items. The seventy one (71) item test was thereafter administered on thirty four (34) NCE III students outside the study area. The reactions of the students to the test were noted and the result used for item analysis. The test item analysis provided basis for reducing the test items to forty (these were items with difficulty indices between 0.35-0.75). The forty (40) items were administered on another sixty (60) NCE III students and the results were analyzed using Kuder-Richardson formula 20. The reliability index obtained was 0.875.

Science Process skills worksheets (SPSW)

The work sheets were developed by the researcher to assess the pre-service teachers' science process skills during every lesson. Each contained eight activities in form of

questions assessing ability to observe, identify, classify, measure, formulate hypothesis, gather data, test hypotheses, and making inference based on data collected.

Teachers' Instructional Guide on Problem-Based Learning Strategy (TIGPBLs).

This outlines the steps involved in presenting the PBLs package to the pre-service teachers in problem based learning group (Experimental group I); it has three phases:

- (i) Problem presentation by the instructor
- (ii) Self-Study/research, students work on issues.
- (iii) Class presentations and summary/conclusion.

Teachers' Instructional Guide on Conventional Lecture method (TIGCLM)

Here, students sit individually throughout the lesson. The treatment for each lesson is in form of lecture.

- (i) The instructor presents the lesson in form of lecture
- (ii) Students listen to the teacher and write down chalkboard summaries.
- (iii) Students ask the teacher questions on areas of the topic that is not clear to them.
- (iv) Students answer the teacher's questions individually.
- (v) Students are given take home assignment.

The manual in form of lesson note was prepared by the researcher and supplied to the instructors.

Research Procedure:

The investigator, six (6) instructors used the four instruments to collect the required data directly from the selected Colleges of Education. To ensure uniformity and clarity in the data collection, the six instructors were trained on how to use the instruments, purpose, principles and procedures governing each group and the use of each treatment. The training involved orientation; discussion and practice and lasted for two weeks. This was done on college basis because the colleges operate different academic calendars.

The instructors were also trained on how to administer the instruments. The Pre-test materials were given to the trained instructors shortly after the training. Their first contact with the students in the classroom was to introduce the package, prepare the pre-service teachers' minds and inform them of the purpose, principles and procedures governing the research. The students were also told the benefits of fully participating from the beginning of

the programme to the end. More importantly, this research incorporated topics to be taught during the second semester and that it would contribute to their semester's examination. They were reminded that the course lecturers, who are the research instructors, might not have another opportunity to re-teach these topics before the semester's examination. After the introduction, the pre-test was administered. This included the Physics Achievement Test (PAT) and demographics. This lasted for one hour which was fixed after the trying out period. The pretest was done in the first week. Treatment group and the control group used all the periods slated for the course that is, two hours per week and the treatment lasted for six weeks after which the post test was administered. The trained lecturers (instructors) taught as directed and in accordance with the objectives of the treatments.

Method of Data Analysis

The data obtained from the pretest and post test were analyzed, using Analysis of Covariance (ANCOVA) with the pretest scores as covariates. Where the main effects were significant, the multiple classification analysis (MCA) technique was used to find the direction of the difference among the groups.

Result

Table1 Summary of Analysis of Covariance of Physics Achievement Test (PAT) Scores by Treatments,

There is no significant main effect of treatment on pre-post Service Teachers' Achievement in Physics Concept

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Covariates	8266.387	1	8266.387	58.277	.000	Sig.
Main effects	12025.799	2	6012.899	42.390	.000	
Treatment Groups	12025.799	2	6012.899	42.390	.000	
Explained	20292.186	3	6764.062	47.686	.000	
Residual	26667.000	188	141.846			
Total	46959.186	191	245.860			

Table1 Shows that there is significant main effect of treatment on pre-service teachers' achievement in physics concepts

$$F_{(2,174)} = 43.447, P < .05.$$

Hypothesis 1a is therefore rejected.

In order to determine the magnitude and direction of the observed significant effect, Multiple Classification Analysis (MCA) was carried out and the result shown in table 2.

Table 2: Multiple Classification Analysis(MCA) showing the direction of the difference of treatment on pre-post Service Teachers' Achievement in Physics Concept

Grand Mean = 40.02

Variable + Category	N	Unadjusted variation	Eta	Adjusted for independent covariates + deviation	Beta
Grand Mean = 40.02					
Treatment Groups:					
Experimental I	47	12.48		11.99	
Experimental II	85	-1.69		.03	
Control	60	-7.38		-9.44	
			.48		.51
Multiple R-squared					.432
Multiple R					.657

From the data in the MCA Table 2, the students in problem-based learning experimental group had the higher adjusted mean score in achievement ($x = 51.98$; $adj. dev. = 11.96$) than the control group conventional lecture method with mean score ($x = 30.23$, $adj. dev. = 9.79$). This order can be represented as $PBL > CLM$. MCA in table 4.2 also shows that the treatment main effect accounted for 27 percent $(.52)^2$ of the observed variance in data.

Discussion of findings

The major issue addressed in this study was to determine the effect of problem-based learning instructional strategy on NCE pre-services' achievement in physics and science process skills acquisition. Over the years, the decline in students' achievement in physics has

been attributed to the teacher-centered teaching methods with the teacher dominating at the expense of students not being encouraged to construct their own knowledge or take active part in their learning. The problem has also been compounded by the abstract nature of some of the physics concepts coupled with the high quantitative demands of the subject. In this study therefore, problem-based learning strategy shifted from the teachers to the students who the strategy sought to empower to take charge of own their learning.

The results of this study showed that the problem-based learning instructional strategy was superior to the conventional lecture method in enhancing achievement in physics concepts over what is attainable with conventional lecture method. This findings is in agreement with the findings of Iroegbu (1998) who reported that problem based learning instructional strategy enhances physics achievement, problem solving skills and line graphing skills over what is attained with conventional instruction in secondary schools. This is also in agreement with the findings of Gbolagade (2009) and Adedigba (2002). Problem-based learning instructional strategy was also found to enhance the acquisition of science process skills significantly. This is in line with the report of Yilman (2005) and Miller (2004) who separately repoted that problem-based learning facilitates cognitive and science proces skills development.

This may not be unconnected with the rigorous hands and mind on materials associated with the strategy. In this research group, students were allowed to take charge of their learning as Kinshuk (2003) reported that it has been found that students are able to learn and retain knowledge better by actively participating rather than learning passively. In the PBL classes, students work in teams to solve one or more complex and compelling ‘real world’ problems. They develop skills in collecting, evaluating, and synthesizing resources as they first define and then propose a solution to a multi-faceted problem. Students also summarized and presented their solutions. The instructor only facilitated the learning process by monitoring the progress of the learners and asked questions to move the students forward in the learning process; the instructor was not the sole resource for content or process information, but instead guided students as they searched out appropriate resources (Major and Palmer, 2001).

So as Major and Palmer (2001), had reported earlier that this strategy provides students with the opportunity to gain content knowledge and skills, it helps students develop advanced cognitive abilities such as critical thinking, problem solving and communication skills and improve students’ attitudes toward learning. So it is not surprising that students in this study group did better than those in the control group.

Conclusion

Based on the findings of this study it could be concluded that problem-based learning instructional strategy improve student achievement in physics and acquisition of science process skills of NCE students than the conventional lecture method.

Recommendations

On the basis of the findings above and the general experience during this study, the following recommendations are considered necessary.

1. Teacher educators should be discouraged from using teacher centered instructional strategies in training pre-service teachers but learner-centered instructional strategies such as problem based learning strategy should be used. The periodic use of such and other innovative strategies will promote high level learning achievement as well as acquisition of science process skills.
2. The NCE curriculum should be revised to move away from content-based to competent-based because the knowledge in science is dynamic and not static and to cope with these changes the teacher should be equipped on how to access and use this new knowledge.
3. The assessment of teachers should be revised so that both content, knowledge and science process skills may be assessed during all examination not only during practical.
4. Physics teachers (educators) should be encouraged to use appropriate learning programmes to facilitate hand on practices to prove that physics is not as abstract as many people think.
5. Facilities should be provided for the retraining of teachers in the use of innovative techniques in science instruction through seminars and workshops.

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